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West Europe Report

SCIENCE AND TECHNOLOGY

FRG: FUNDED PROGRAM FOR THE DEVELOPMENT OF MICROPERIPHERALS

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Bonn INFORMATIONSTECHNIK: MIKROPERIPHERIK [INFORMATION TECHNOLOGY: MICROPERIPHERALS] in German, 1985 pp 1-35

CONTENTS

[TEXT]
PREFACE

The broad range of applications of microelectronics plays a key role for the Federal Republic of Germany. The field of microelectronics is a critical factor in our industry's ability to compete in international markets and therefore directly influences our prosperity and the employment situation in our country.

International competition has become fiercer. Efficient and productive domestic supplying industries are becoming increasingly important. This is true not only of microelectronic compo nents themselves; the availability of advanced peripherals that are compatible with microelectronics, such as state- of-the-art sensors and utility electronics are at least as important for machine construction and for the electrical and automotive industries. In these areas, research and industry are confronted with serious technological challenges. In the Government Report: Information Technology ["Informationstechnik"] the Federal Government for this reason decided to increase its support for research in the area of microperiperals in order that significant bottlenecks in this area can be overcome as rapidly as possible.

The predominantly mid-sized companies that manufacture sensors must use new technologies to develop microelectronics-compatible sensors. The new sponsorship measure "Microperiperals" is intended to speed up this development by offering support in the utilization of state-of-the-art miniaturization technologies for the development of intelligent sensors.

The most suitable form of sponsorship, indirect-specific support, is an instrument of the market economy, a type of support that allows the business in question to make independent decisions concerning product development. In this way, the use of new technologies can be accelerated without affecting market mechanisms.

Another important aspect of this program is the intensification of long-term joint research by industry and research institutes in the area of future technologies for state-of-the art micro-peripheral components. Only if we are able to coordinate our development efforts more closely than was previously the case will these efforts have the necessary impact in terms of international competition.

With this step, the Federal Government hopes to make an additional contribution to economic stability.

[signed,]
Dr. Heinz Riesenhuber
Federal Minister of Research and Technology

Summary

The special program "Applications of Microelectronics" (1982-1984) gave the initial push towards a broad use of microelectronics technology in new products. This is especially true for the predominantly mid-sized, export- oriented sectors of mechanical engineering, industrial electronics and measuring and control equipment for laboratory and facilities construction.

In this regard, the availability of modern peripheral components, i.e. sensors and utility electronics, is becoming increasingly important. As necessary components in coupling microelectronics to a process that is to be controlled or supervised, they determine to a large extent the efficiency and the cost of an entire system.

In addition to rising demands and new requirements, the field of micro- peripherals is undergoing a profound technological transition. A decisive factor will be the speed with which the predominantly mid-sized sensor manufacturers will be able to introduce the necessary technologies, which today are ready to be implemented but which require large investments and constitute high risks.

In order to guarantee long-range competitiveness, an internationally competitive basis of know-how in the technologies must be created for future micro-peripheral components. The prerequisite for this is timely and close cooperation between research and industry.

To support these efforts and to make available the needed funds in an appropriate way is the objective of a newly approved sponsorship focus "micro- peripherals" (1985-1989), within the framework of the government report "Information Technology," for which DM 400 million in federal funding have been apportioned.

The measure consists of three parts:

1. The indirect-specific support of projects for the development of microelectronics-compatible sensors with integrated, intelligent signal pre- processing capabilities, using modern miniaturization technologies (surface mounting, thick film, thin film and semiconductor technologies). This measure, which is to be carried out in the time period 1985-1988, is intended to facilitate the rapid use of these technologies in particular for the predominantly mid-sized sensor manufacturers.

2. The sponsorship of future-oriented joint projects in selected important technological fields for future micro-peripheral components.

3. Technology transfer, especially the support of mid-sized manufacturers.

I. Initial Situation and Future Development

Applications of Microelectronics and the Significance of Microperipherals

In recent years, German industry has greatly stepped up the development of a broad range of microelectronic applications in new products. With the special program "Applications of Microelectronics," which was funded from 1982 to 1984 at a cost of DM 450 million, a positive development was brought about and accelerated on a broad front. The impetus was concentrated in machine construction, industrial electronics, the industries supplying auto manufacturers, measuring and controlling technologies as well as in the laboratory equipment industry and the predominantly mid-sized businesses which are active in these industries.

The development of microelectronics is characterized by a rapid increase in the efficiency of components and by steadily falling costs. This makes it possible for microelectronics to penetrate application areas which can only be efficient and economically competitive if total costs for a microelectronics system (including sensors, effectors, utility electronics, keyboards and displays) are kept relatively low. Examples include motor performance control in motor vehicles and detergent feed control that depends on the degree of contamination of the wash water in washing machines.

Microperiperals, i.e. sensors and utility electronics, today increasingly determine the cost and the possibilities of the implementation of microelectronics in new applications.

Utilizing physical effects, sensors convert physical values such as pressure,, temperature, position, flow rate, moisture, ion concentration, etc. by using physical effects to generate electrical values that can be further processed. Utility electronics is used to select control elements, drivers, etc. These microperiperals thus interface microelectronics with the environment or with a process that is to be controlled.

The most important requirement of modern microperipheral components, in addition to low cost, is the simple and economical adaptability to microelectronics. This requires advanced technologies. Research and industry are confronted with a challenge that can only be met with great initiative. The approximately 500 predominantly mid-sized companies which manufacture sensors in the FRG must accomplish a move to new miniaturization techniques which are needed for the realization of sensors compatible with microelectronics with integrated signal pre-processing.

In order to secure a favorable competitive position for the future in new sensor design and technologies, research efforts must be greatly intensified and the corresponding laboratories must be expanded. A decisive factor will be whether efforts to bring about closer cooperation between research groups at the universities, institutes and industry are successful.

This is also true of utility electronics which is such a critically important area for machine construction. In this regard, manufacturers and research groups from the universities and

the Fraunhofer institutes have joined together in a combined effort to develop basic utility semiconductor technology. These efforts are intended to make it possible at least to keep up with our most important competitors and to ensure that the basic needs of German industry are met.

The speed with which research and industry succeed in carrying out this task will have a direct impact on the efficiency and competitiveness of the products of our export industries, machine building and the electrical and auto industries, which in 1983 registered annual sales of DM 420 billion and an export surplus of DM 148 billion.

The wide-ranging application of microelectronics to the economically important areas of energy and raw materials conservation and environmental protection will only become economically feasible when low-cost, state-of-the-art microperipheral components are available.

Because of the necessary spirit of cooperation and mutual trust that must exist between manufacturers and users of microperipheral components in the early phases of development, dependence on foreign manufacturers would be disastrous. Therefore, efficient domestic microperipheral manufacturers are of great importance if industry in the FRG is to remain competitive.

Not only the possibilities of the rapidly growing market for microperipheral components are significant in terms of employment policy. Securing an appropriate share of the market for advanced microelectronic applications using state-of-the-art microperipheral compo - nents is even more important.

For example, the sensor market is an indicator of the economic importance of the corresponding microelectronic applications. Experts estimate that the world market for low-cost sensors that can be interfaced to microelectronics will reach c. DM 3 billion, increasing annually by c. 30 percent.

In terms of manufacturing volume, the automotive industry is regarded as the most important growth market. Other important markets include household appliances, heating and cooling systems, personal property and fire protection, environmental measuring technology and industrial electronics, especially the growth fields of microelectronic applications in mechanical engineering and the electrical appliance industry.

If we lag behind Japan and the USA, our most important competitors, this would have direct, negative consequences. The objective of the new sponsorship focus for "microelectronic peripherals" is the timely creation of the prerequisites needed to ensure a position of international leadership.

New Technologies and the Challenge to Research and Industry

Sensors and utility elements of utility components are discussed in the following section as examples of the most important areas within the field of microperipherals.

Sensors

Among the manufacturers of sensors, intensive efforts are underway to gradually optimize sensor performance data and manufacturing processes. Even though some of the developmental work involved in these efforts has been very costly, sensors of this first generation are not to receive financial support.

The necessity for state funding measures is created by the technological transformation that effects broad areas of sensor technology.

The demands made on modern sensors include

- minimal interfacing requirements when used with microprocessor systems;
- the possibility of anonymous exchange of sensors of the same type, i.e. replacement without the need for adjustment;
- no adjustment of manufacturing tolerance levels and temperature drift on the part of the user;
- output signal compatible with microelectronics.

These demands led to the development of sensors of the second and third generation, i.e. sensors with integrated signal pre-processing.

In the case of most of the first-generation sensors that are developed and used today, the sensor is a separate component. Its signal must be conditioned externally; after analog/digital conversion, it can be subsequently processed in a microprocessor.

For sensors of the second and third generation, intelligent signal pre- processing and the sensor share the same housing, so that the output signal can be processed directly.

With second-generation sensors, the requirements of moderns sensors as listed above can be met. The use of modern miniaturization technologies such as surface mounting, thin film, thick film and semiconductor technologies for signal pre-processing is a prerequisite for cost-effective, second-generation sensors.

Of the roughly 500 predominantly mid-sized sensor manufacturing companies in the FRG, at the present time very few are producing second-generation sensors. Most of the manufacturers, however, are about to move into or are already in the introductory phase of the necessary and relatively expensive technologies needed for this. In addition, sizeable

investments are necessary for the outfitting of corresponding laboratories and initial product development in the new technologies requires large expenditures. This entails heavy financial burdens, especially for mid-sized companies.

Parallel to the introduction of these technologies, intensive work is being carried out all over the world on future-oriented designs for new, intelligent and very cost-effective sensors of the second and third generation, which are based on integrated optics, semiconductor technology and technologies derived from the latter. Worldwide, however, only a few laboratory prototypes or individual solutions are in e
istence at the present time.

Examples of these new technologies include micro-mechanics and the concept of ion-sensitive or gas-sensitive field effect transistors. The field of micro-mechanics, which is based on the use of etching methods in semiconductor technology, makes it possible to etch the thinnest membranes or fine channels into silicon. This results in many possibilities for new sensors with integrated signal pre-processing on one chip.

The concept of Ion Sensitive or Gas-sensitive Field Effect Transistors (ISFET/GasFET) is based on the field effect transistor structure in which the gate electrode is replaced by an ion-sensitive layer.

This concept of ISFETs and GasFETs makes it possible to manufacture inexpensive multi-sensors with fully integrated signal processing for measuring concentrations in solutions and gases with all the advantages (intelligence, cost, etc.) that are known from the sweeping developments in microelectronic components. Experts reckon, however, that such sensors will not be manufactured until the end of this decade or the second half of the 1990's. The major obstacles lie in the chemistry of the sensitive layers, the physical structure of the surface and the development of processes for applying these films that are consistent with the use of semiconductors. In order to solve these problems, cooperation among specialists from the various scientific disciplines is necessary.

The revolutionary significance of these developments particularly effects measuring techniques in important areas of medicine, environmental protection and energy conservation. Examples are disposable sensors for population studies for the determination of blood data, in the long run perhaps a blood sugar sensor for the artificial pancreas; exhaust sensors for the control of oil burners and diesel engines to reduce exhaust emissions and to help conserve energy; washing machines with automatic liquid detergent feed regulation that depends on pH content, hardness, turbidity and temperature of the wash water.

It is important that very comprehensive and protracted preliminary studies be initiated today so that an internationally competitive basis of know-how is created in time to meet the needs of tomorrow. For this reason, the research activities carried out by research institutes and industry must be intensified and merged together.

Utility Components

The capabilities of microelectronics to carry out refined and faster control operations can be better utilized if utility components are available which make it possible to select control elements and drives at reasonable cost and with corresponding technical performance data.

The requirements of the most advanced utility components with regard to simplified selecting, high switching frequencies, improved overload protection, etc. can only be met when the physical processes in the semiconductor and the ways in which they can be influenced are better understood, and proven methods from the field of microelectronics are implemented in the construction of more refined structures and adapted for integration in utility components. Examples of this would be the implementation of computer simulation for the optimization of semiconductor processes as well as for the optimization of the switching properties of the utility semiconductors which are dependent on component design, questions of an improved understanding of the response time for attaining equilibrium in a charge carrier, new kinds of doping techniques, etc. Large-scale financial support is needed for this, as was the case in the past for microelectronics.

II. The Concept of Sponsorship

Support in the comprehensive area of sensors and effectors can only be effective using available funding when such support is concentrated on selected focal areas and when the particular form of sponsorship best suited to each particular case is utilized.

The already-proven instruments of indirect-specific support for a broadly effective speed-up in the use of technologies that are ready to be implemented and the sponsorship of joint projects in future-oriented research and development are being used.

1. Indirect-Specific Support

This measure focusses on the overall advancement of the development of sensors that are compatible with microelectronics, with intelligent, integrated signal pre-processing. At the same time, the broad use of the modern application- ready miniaturization technologies necessary for this, especially in smaller and mid-sized enterprises in this area, is to be stepped up.

Indirect-specific support is the instrument best suited for this. Its essential features are:

- no state influence on the basic idea for a new product and the course of development of this product;
- significantly reduced expenditures for the application process, approval, accounting and proof of disposition of funds.

In one specific, clearly delineated technological field (specific aspect), all R&D work related to product development in a simple, broadly effective process is supported. Judgement of the correctness of the individual corporate decisions concerning product development is left to market forces (indirect aspect).

The measure is restricted to the period 1985 to 1988, with final budgetary statements to be rendered in 1989. Funding allocated for the purposes of indirect-specific sponsorship amounts to DM 200 million.

2. Sponsorship of Joint Projects

In the view of representatives from research and industry, the mid-range and long-term competitiveness of the manufacturers of microperipherals can most effectively be secured if support is concentrated on the development of an internationally competitive know-how base in the most important technologies. This know-how, which is acquired in jointly established focal areas, can then be used by industry to spin-off many different kinds of product developments. Prerequisite for this is the timely and close cooperation between research and industry.

The instrument best suited for this is the support of joint projects.

Funding will be made available for multi-disciplinary research and development projects that are characterized by a high degree of development risk, high financial costs and a joint interest on the part of various users in the know- how that is to be acquired. A coordinated and clearly defined collaboration by businesses and research institutes is in all cases an important prerequisite for the success of these projects.

Detailed discussions with representatives from research and industry at several status seminars have led to plans for the following focal areas:

- micromechanics for sensors;
- integrated optics for sensors;
- technologies for chemical sensors;
- technologies for modern utility components;
- basic studies related to problems encompassing all areas of microperipherals (interfaces, miniaturization and design technologies, etc.).

The principles underlying project support are valid for this sponsorship.

As a rule, the subsidy will amount to 50 percent of total costs. In the case of projects carried out by research institutes, a 50 percent participation by industry should be targeted.

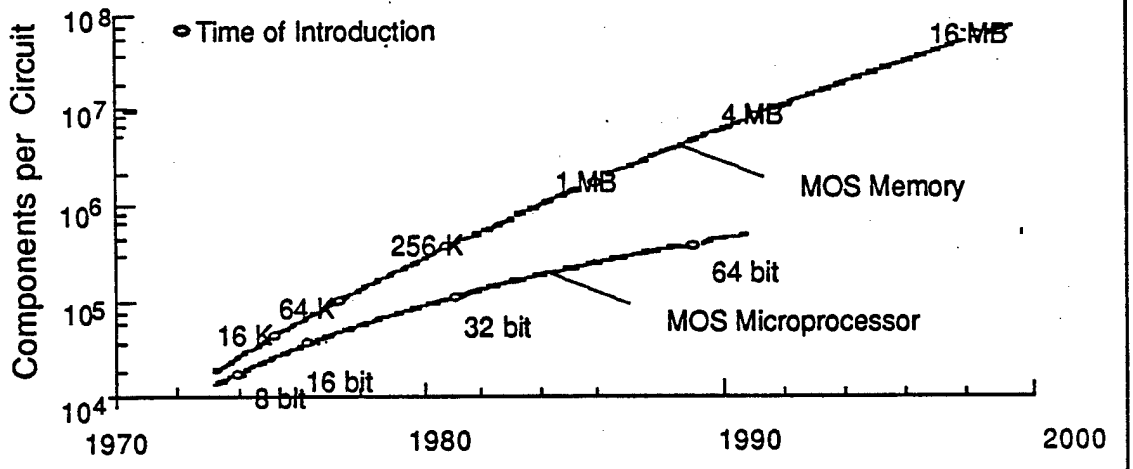
3. Technology Transfer

Measures to improve the transfer and dissemination of R&D results are an important means of speeding up the broad application of innovations. For this reason, especially the current activities of the project institution, the VDI Technology Center for Information Technology with regard to technology transfer (e.g. publications, workshops, seminars, discussions, participation in trade fairs) are to be intensified. The target group consists above all of small and mid-sized businesses.

Also to be mentioned in this regard is the thick-film and hybrid technology laboratory which was established in 1982 with federal funding at the Fraunhofer Institute for Solid-State Technology in Munich, for the advanced training of specialists from mid-sized companies.

development will make it possible in the future to design new products and systems solutions that today are not yet attainable for economic or technical reasons. Data processing and communications will become an inseparable totality, altering not only operations in industry, but also in the service sector, which as a user of new information systems will be affected by changes in information technology, as is already evident today, for example in monetary and credit matters.

Illustration 3



Examples for the Increase in Circuit Complexity
Source: VDI Technologiezentrum

II.4 Influence of Information Technology on the Employment Situation

For the entire economy, information technology is a means of increasing productivity and thus of improving its competitive ability. As the most recent studies show, there is no direct causal connection between a decline in the number of jobs and an increase in labor productivity. According to these studies, over the past ten years in the FRG a decrease in the number of jobs has been registered in those areas in which labor productivity has risen at a below-average rate. Changes in the labor market resulting from this are difficult to evaluate for individual technologies.

Information applications in the production process and products of modern national economies bring about a structural transition which sets free strong growth impulses in those industrial countries which actively take advantage of this structural change. The ability to participate in growth markets by means of the innovative utilization of information technology means having a good chance in the international competition to create new jobs, to replace obsolete jobs by new ones and to make existing jobs more secure for the future by means of modernization. If the FRG does not take advantage of the innovation potential of information technology, old jobs would become obsolete in this country, but new jobs would be created in other industrialized countries.

In this process, a decisive role is played by the education and continuing education sector. Information technology means in many sectors that routine operations and quantifiable procedures will no longer be carried out by human beings, but rather by machines which are programmed by human beings. For this a continuing ability to learn, an ability to deal with

III. Financial Need

In order to finance this focal area of sponsorship, DM 400 million will be made available for the period 1985 to 1989, DM 200 million of which are to be used for indirect-specific support.

In the relevant budgetary plans (Title 3004, 683 46), the following amounts are budgeted for 1985-1989:

	1985	1986	1987	1988	1989*
in mill. DM	45.4	75.6	94.7	94.2	(90.1)

*the relevant budgetary planning ends in 1988

All of these measures will be handled by the project institute for "Microperipherals," the VDI Technology Center for Information Technology in Berlin.

Appendix 1:
The Indirect-Specific Sponsorship Measure

This sponsorship measure will begin on March 1, 1985, and will end on December 31, 1988. An outline of its most important aspects:

What is being sponsored?

Support is made available for the development of microsensors that consist of one or more sensor elements and a signal pre-processing unit that shares the sensor housing.

In terms of this guideline, /sensor elements/ means elements without housing that convert physical or chemical values directly into electrical values.

Signal pre-processing for the sensors to be developed must be so intelligent that the output signal is largely free of shortcomings due to the measuring method or manufacturing process (e.g. temperature variation, offset, linear distortions, sample deviances with regard to sensitivity and transverse sensitivity). An additional signal interpretation outside the microprocessor shall thereby become superfluous. The microsensor must be interchangeable with regard to its type-specific exit signal without any further calibration.

In the case of microsensors which are used under extreme environmental conditions (e.g. high temperatures, extreme area), the sensor element and the signal pre-processing unit may be housed separately. The intelligent, hybrid- integrated signal pre-processing may in this context not be regarded as an independent product. In addition to the outlined characteristics, a separately housed signal pre-processing unit must be designed for the interpretation of maximum values, gradients for other supervisory functions or automatic calibration.

The entire integrated signal pre-processing must be based on integration technologies such as surface mounting and hybrid and semiconductor technology.

The development of measuring systems or of signal pre-processing in conventional technologies (printed circuit board) will not be supported.

What Form May Sponsorship Take?

In order to make it possible for businesses to familiarize themselves with the necessary technologies, a preliminary phase can precede the actual development phase. A preliminary phase may also be necessary when the concept has not been explored. The time frame for the sponsorship of a preliminary phase is limited to six months.

The development phase begins when a completed plan has been prepared after preliminary work has been concluded. All aspects of development work, including the testing of prototypes, is eligible for support. At present, sponsorship is limited to a development period of 30 months.

The largest subsidy available per company amounts to a total of DM 400,000 for the duration of the sponsorship measure, of which up to DM 50,000 can be used for the preliminary phase. If the company also develops the sensor elements (using thick film, thin film or semiconductor technologies), the maximum subsidy increases to a ceiling total of DM 800,000. Up to this maximum subsidy, grants may be awarded for several development projects. The non- repayable grant covers 40 percent of the following project costs:

- costs of personnel with higher technical qualifications (physicists, chemists, engineers, technicians) with a fixed sum of DM 12,000 per man/ month. (The costs for other personnel may not be brought into account. This lump sum is expected to cover individual salaries, incidental personnel costs and overhead as well as travel expenses, material costs, and the cost for special training courses related to the technologies mentioned above. Training time will be regarded as personnel time and may be taken into account);
- individual costs for R&D contracts to third parties (businesses or institutes involved in specialized technologies);
- individual costs for technological consulting by third parties;
- individual costs for new laboratory equipment and installations that meet industry standards.

In this regard, the amount of grant money available for costs involved in contracting third parties and technological consultation by third parties is limited to the amount of the grant needed to cover the costs of the firms own permanent staff. Exceptions are only possible for contracts for the development of integrated circuits. Allotments for the costs of laboratory equipment and installations is limited to 20 percent of the total grant for the development phase.

Who can be Sponsored?

Manufacturing companies from all sectors are eligible to apply for the program, as long as they

- manufacture sensors and wish to manufacture micro-sensors or
- possess the necessary laboratory and manufacturing installations for the development and production of micro-sensors using hybrid, thick film, thin film or semiconductor technologies and intend in the future to manufacture microsensors.

Sensor manufacturers according to these guidelines are companies which

- themselves develop and manufacture sensor elements or sensors with purchased sensor elements,
- distribute these as products or have them distributed and
- can show a corresponding annual sales figure of at least DM 1,000,000.

What Prerequisites Must be met by the Company?

At the time of applying for sponsorship of the development phase at the latest, the company applying for support must demonstrate that it has its own laboratory equipment and installations, which are suitable to develop microelectronics-compatible, miniaturized sensors in the named technologies (semiconductor, thin film, thick film, hybrid or surface-mounting technologies (SMD) and that it can carry out the essential process stages in its own laboratory.

A "minimum of equipment" in accordance with the guidelines is for

- *Surface-Mounting Technology**
  a screen printing machine, inserter [for populating IC boards] or wave soldering machine;

- *Hybrid Technology**
  An installation for the manufacturing of films in thick film and thin film technology, inserter, bonder, soldering machine;

- *Thick Film Technology**
  Screen printer, drying strip, burning-in furnace, sand smoothing process or laser trimmer;

- *Thin Film Technology**
  dust-free work place (flow box), ultrasonic cleaning equipment, physical vapor deposition devices or sputtering machines or CVD or plasma reaction chambers, a thickness measuring device, a burn-in station, microscope.

- *Semiconductor Technology**
  dust-free work place (flow box), devices and installations for the preparation of wafers, photo lithography, etching technology and the production of isolator coverings, wafer probes.

In every case, an electronics laboratory with facilities for the testing of sensors must be part of the minimum equipment of each company.

How Can I Apply for Support?

The application is to be sent on the application forms for "Microperipherals" to the VDI Technology Center for Information Technology in Berlin. The VDI Technology Center as the sponsoring organization has been commissioned with the processing of the sponsorship measures. The BMFT decides on sponsorship at the suggestion of the sponsoring institution.

*cf. Appendix 2

How Are Funds Handled?

The grant-in-aid covering the preliminary phase is paid after the conclusion of this phase. For the development phase, the grant-in-aid is paid out in stages at the end of every quarter. At the end of the year, an interim report must be submitted concerning the progress of the project. Furthermore, upon conclusion of the undertaking, an audit report on the utilization of the funds must be submitted. The statements are to consist of the cost accounting and a brief formal report.

What Else Should I Know?

The guidelines according to which the BMFT decides upon the sponsorship of projects are spelled out in the "Guidelines: Microperipherals" ["Richtlinien Mikroperipherik"] and the rights and obligations of the sponsored enterprises are described in the "Incidental Provisions: Microperipherals" ["Nebenbestimmungen Mikroperipherik"].

A few important points:

- There is no entitlement to a grant-in-aid.
- The proposed project is defined by the activities described in the application.
- The project can only begin during the month in which the application is received at the VDI Technology Center for Information Technology in Berlin.
- The beginning and end of the time period covered by the grant are spelled out in the terms of the grant. Changes in the terms must be requested during the duration of the project.
- Reports will not be published.
- Rights of use resulting from the R&D projects remain the property of the enterprise.
- Appropriations can be withdrawn and the grant must be paid back if the sponsored enterprise cannot produce proof of utilization of funds or if the business has not observed other obligations spelled out in the "Incidental Provisions: Microperipherals."
- Contracts awarded to foreign businesses can only receive grants-in-aid if this is necessary for technological reasons.

To Whom Do I Apply?

Project Sponsor VDI Technologiezentrum Informationstechnik
Budapester Strasse 40
1000 Berlin 30
Phone: (030) 26 09 - 153

Appendix 2:
Notes on the Technologies

Surface Mounting Technology

In surface mounting, miniaturized passive and active semiconductor components, called "Surface Mounted Devices" (SMD) are soldered directly onto the surface of the substrate; eyelets are not needed. SMD can be mounted on hybrid substrates as well as on one or both sides of normal printed circuit boards. The populating can be carried out either exclusively with SMD or together with wired components, manually, semi-automatically or in a fully automated fashion.

SMD technology is comparable to hybrid technology with regard to compactness, reliability and error frequency, but in terms of price and flexibility it is comparable to normal printed circuit board technology.

Because of this combination of properties, surface mounting is especially well suited for the signal pre-processing of sensors, which on the one hand must be miniaturized, reliable and trouble-free, but which on the other hand have to be adaptable to the ever-changing new measurement problems.

Thick Film Technology

In thick film technology, structured films with very specific electric properties are laid down on an electrically neutral substrate, using primarily screen printing processes. The smallest possible physical size of the structures is approximately 100 micrometers film width by 10 micrometers film thickness. The use of various thick film pastes that are available on the market can create printed circuits, capacitors or resistors with various characteristics. Thick film resistors manufactured with photoconductive pastes are used as light barriers, capacitors with moisture-dependent dielectric are the basis for moisture sensors; solid electrolytes applied in thick film technology react in the presence of chemical substances.

Thick film technology is thus well suited for the manufacturing of miniaturized sensor elements.

Thin Film Technology

Thin film technology has been used for years in the manufacturing of semi- conductor contacts, passivations and insulations, of optical protective films, tempering and filtering as well as in the design of high frequency hybrid circuits, and at present it is used to an increasing extent in the manufacture of sensors.

In order to create films which are between .1 and 1 micrometers thick, various processes are used, such as physical and chemical vapor deposition; other, less frequently used methods include spinning, dipping, anodic and thermal oxidation.

As film materials, metals, insulation and semiconductor materials, but also organic substances are used. The films are deposited on insulating, conducting rigid or flexible substrates according to the intended application.

Thin film technology is suited for sensor elements for almost any measuring application from strain gauges (DMS) for measuring force and pressure to moisture and chemical sensor elements.

Hybrid Technology

In hybrid technology, layered structures with distinct conductive properties are applied to an insulating material and combined with separate components in an unpackaged or miniaturized design. The layers are produced using the methods of thin film or thick film technology. Hybrid technology can be easily mastered and is suited both for the cost-effective manufacturing of test patterns as well as for the production of large series of circuits for signal pre-processing.

Semiconductor Technology

In semiconductor technology, topologically defined areas in semiconductor crystals are altered in their electrical properties with the help of selected doping techniques. This serves the design both of discrete components and of integrated circuits in planar form. The dependence of electrical properties on environmental conditions such as temperature, radiation, pressure or the presence of magnetic fields is quite pronounced in some semiconductors. These effects are utilized in semiconductor sensors, which have already established for themselves a firm market share. In the production of these sensors, processes used in the production of discrete components are utilized.

In contrast to the conventional semiconductor technology, the new technology of /silicon micromechanics/ offers the possibility of creating three-dimensional structures such as membranes or gates. The thickness of these structures can be as small as two micrometers with a lateral extension of .1 to 1.0 millimeters. Configurations of this type are utilized for micro sensors, for example to measure acceleration, to analyze oscillation frequencies or for pressure measurements.

In the manufacturing of micromechanical components made of silicon, in addition to well-known photolithographic processes selective and anisotropic etching techniques are also used. In this specialized technique, etching speed, which depends on crystal orientation and impurity atom doping, varies by a factor of 200. With the crystal solution acting upon the crystal for a limited amount of time, complex three-dimensional structures can be created.

Very Large Scale Integration

Very Large Scale Integration [VLSI] technology makes it possible today to accommodate up to 450,000 active logic gates on one semiconductor crystal (IC). In addition to the completely new development of an integrated circuit, during which each transistor has to be individually designed and positioned on the chip, there are also developments with e.g. gate arrays and standard cell arrays. Here, only the wiring of prefabricated elements is to be determined by the developer.

Because of the small dimensions and low energy requirements, VLSI IC's are excellently suited for information processing and the communication of sensor signal data.

In microsensors based on semiconductors, IC's can be directly integrated with the sensor element on a single chip.

APPENDIX 3

Stages of Support

I. Preliminary Phase

Grant-In-Aid:	up to DM 50,000 (one-time award)
Duration:	up to 6 months
Payment:	retroactive
Request for Payment:	is made together with demonstration of use
Interim Report:	N/A
Demonstration of Use:	upon conclusion of the project; presentation of expense reports for third-party consultation; presentation of personnel cost summary; formal summary report

II. Developmental Phase

Grant-In-Aid:	to DM 400,000, or DM 800,000 including Preliminary Phase
Duration:	up to 30 months
Payment:	retroactive
Request for Payment:	at the end of each quarter; presentation of offers; interim accounting or accounting for R&D contracts and technical consultation by third parties; Presentation of invoices and statements for laboratory equipment and facilities; summary of personnel costs
Interim Report:	annually at the end of each calendar year, if the project does not terminate at the end of the calendar year. Presentation of documentation that may not yet have been handed in; summary of personnel costs; formal project report
Demonstration of Use:	upon completion of the project; presentation of documentation that is still outstanding and of a summary of personnel costs; formal project report

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